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HENRY HORNER, Governor

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DEPARTMENT OF REGISTRATION AND EDUCATION
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LIST OF SPEAKERS

A committee designated by the Council of the Academy has prepared a list of speakers who are willing to present talks on various phases of science before interested groups. Unless otherwise indicated, these speakers are willing to give their services for expenses only. In some cases a small honorarium is expected. A copy of this list of speakers may be obtained gratis by sending a request to:

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Geological Records of a Rhythmic Nature*

Harold R. Wanless, Ph. D.
University of Illinois, Urbana, Illinois

INTRODUCTION

THE New Century dictionary defines rhythm as "a procedure marked by the regular recurrence of particular elements or phases." Rhythms in the history of the earth have attracted the attention of geologists for more than half a century.[1] The lengths of time represented by described rhythms range from a single day and night sequence to a geologic period. Erosional rhythms or cycles are deciphered principally through a study of the land forms of the earth, but they also reflect their successive stages in the quantity and type of sediment in adjacent basins. Rhythms or cycles of sedimentation are observed through the repeated recurrence of certain layers or sequences of layers in a stratified succession, which thus shows the repeated recurrence of nearly identical conditions. A cycle may consist of no more than two beds, whose total thickness is less than 1 millimeter, or of 15 or 20 lithologic units with a combined thickness of more than 100 feet.

My interest in geological rhythms has been aroused through the studies of the "Coal Measures" of the eastern United States during the past several years. These rocks, representing a considerable part of the time scale, exhibit a "regular recurrence of similar elements or phases" so striking that it can scarcely be regarded as the result of a series of coincidences, and so, despite a recent derogatory remark that the discovery of new rhythms may be regarded as a pleasant pastime to occupy the leisure moments of a geologist between more significant tasks, and because I feel that the study of rhythmic records may aid in determining the duration of various parts of geologic time, in determining the rate of accumulation of various kinds of rocks, and perhaps in discovering evidence of the operation of some little-understood forces in the shaping of the earth, I shall take advantage of my position and my required duty to discuss some of the aspects of geologic rhythms. I shall limit my discussion to rhythms of erosion, rhythms of deposition, and climatic rhythms revealed in the growth rings of trees, both living and fossilized.

EROSIONAL RHYTHMS

The great physiographer William Morris Davis developed the concept of the erosion cycle accomplished by streams in a humid region[2]. He conceived a region newly exposed to the action of running water following elevation above the sea, the wasting of a continental glacier, the draining of a lake, the hardening of an extensive lava flow, or some other phenomenon. He demonstrated that first the growth and integration of a drainage system in an area would gradually destroy the initial surface and leave a rugged, well drained, maturely dissected region. The continuance of erosion would develop new plains by broadening the major river valleys, subdue the relief of the uplands, and ultimately produce a new land surface near the level of the principal streams. This surface, which he termed a peneplain, would be permanent until it was either submerged beneath the waters of the sea

* Address of the Retiring President. Presented before the General Session at the Thirty-first Annual meeting of the Illinois Academy of Science, May 6, 1938, at Carbondale, Illinois.

[1] Newberry, J. S., Circles of deposition in American sedimentary rocks; Am. Ass. Adv. Sci., Proc. 22, pt. 2, pp. 185-196, 1874.

[2] Davis, W. M., The rivers and valleys of Pennsylvania: Nat. Geog. Mag. 1, pp. 183-253, 1889.

or elevated and subjected to the beginning of a new erosion cycle. The complex erosional history of some land areas has been interpreted in terms of several partially completed erosion cycles. The interpretation of multiple erosion cycles is further complicated by the possibility that a high level plain may develop on a resistant stratum contemporaneously with a lower plain on a weaker stratum.

Davis[3] also pictured the erosion cycle in an arid region, where most of the sediment from the uplands accumulates in intermontane basins instead of being carried to the ocean. In the earlier part of the cycle the drainage system is poorly integrated, and numerous basins at different levels receive the waste. As the cycle progresses waste from the higher basins spills over into adjacent lower ones, and the drainage becomes more integrated. As the mass of debris rises in the basins it may bury smaller ridges, thus expanding the depositional plain. Temporary saline lakes are likely to occupy the deeper parts of the basins. In cases of extreme aridity wind becomes a more powerful transportive agent than streams and shifting dunes become conspicuous features of the landscape. In cases of greater or increasing humidity the saline lakes increase in size until ultimately they discharge their waters seaward through some notch in the bounding wall of the basin. The Great Basin region of the western United States affords illustrations of various stages in the arid erosion cycle.

Douglas Johnson[4] has described coastal erosion cycles initiated either by elevation or subsidence of the land with reference to sea level. Wave-cut cliffs are formed along recently elevated coasts, and if the rocks are of unequal resistance to wave attack, headlands and coves may develop. After a time a series of offshore bars or a barrier beach is formed, separated from the mainland shore by a lagoon. The beach is interrupted at intervals by tidal inlets. As the emergent cycle passes from maturity to old age, the offshore bars migrate landward until they merge with the beach. The coast, now fronted by a broad wave-cut bench, straightened of irregularities due to unequal hardness, and protected by a sandy beach, has achieved stability until there is another movement of the land or a change in sea-level.

If the sea-level is raised or the land lowered a deeply embayed coast with irregularly branching promontories characterizes the initial stage. Erosion of the headlands and the building of bay-mouth bars continues until maturity. The coast is ultimately straightened in old age and resembles the corresponding stage for an emergent coast.

Hobbs[5] described an erosion cycle for mountain glaciers. At the outset, glaciers form from snowfields in deep shaded ravines on the mountain slopes. The surfaces between these glaciers are rounded hills or divides. As glacial erosion proceeds, deep U-shaped valleys are carved out and the divides are narrowed until they become steep-sided, saw-toothed ridges with high peaks or horns at intervals along the range. Later erosion reduces the height of the peaks and the area of the névé fields or gathering grounds for the glacier, and the glacier gradually decreases in size due to lack of nourishment, terminating the cycle. Examples illustrating the various stages of this cycle are to be found in the mountain ranges of western United States.

A somewhat different form of erosion cycle is found in areas of limestone bedrock, where solution-widened joints admit the surface water to a labyrinth of subterranean passages. Erosion in such regions is accomplished by solution and the collapse of materials above limestone caverns. Natural bridges, sink-holes, disappearing streams, and giant springs are all features of this karst erosion cycle.

Milner[6], Boswell[7], and others have showed that an erosion cycle on a land area may be interpreted through the sequence of sedimentary units deposited in an adjacent basin. At the beginning of the cycle, deeply

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[3] Davis, W. M., The geographic cycle in an arid climate: Jour. Geol. 13, pp. 381-407, 1905.
[4] Johnson, D. W., Shore processes and shore line development, pp. 199-392, 1919.
[5] Hobbs, W. H., Characteristics of existing glaciers, pp. 25-39, 1922.
[6] Milner, H. B., Sedimentary petrography, pp. 361-371, 1929.
[7] Boswell, P. G. H., On the mineralogy of sedimentary rocks, pp. 37-59, 1933.

weathered residual soils would be the principal source of sedimentary materials, and stable mineral species would predominate. Later, during youth and early maturity, while the streams deepen their courses rapidly into unweathered materials, the sediments will contain numerous unstable mineral species which will afford a clue to the types of rocks exposed in the region providing the sediment. During late maturity and old age, erosion proceeds less rapidly and there is more opportunity for weathering, so that only the more stable mineral species survive destruction. The study of mineral assemblages in sedimentary formations of known geologic age thus affords a check on the number and geologic age of erosion cycles in nearby regions.

TREE RING RHYTHMS

The variable width of annual growth rings in trees seems intimately related to the relative abundance of moisture during successive growing seasons. Studies of growth rings, especially of such old trees as the sequoias of California, affords one of our best records of climatic variations within the last few thousand years. Huntington[8], Douglass[9], and others have done much careful work on tree ring sequences. Douglass found it possible to date the Indian cliff dwellings of the arid southwest through matching growth rings in timbers used in their construction with those of very old trees still growing. He also proved that aridity led to the abandonment of these settlements. By matching humid and arid periods of the California "Big Tree" groves with high and low levels of shore-lines on the Caspian Sea as revealed by the records of historic settlements there, Huntington showed that climatic changes recorded in the tree rings are world-wide rather than local. Tree rings afford an opportunity to study the effects of sun-spot and other solar cycles and have yielded evidences of cycles of lengths ranging from about 10 months to more than 30 years. Petrified wood from various geologic periods indicates by variations in growth rings whether or not seasonal climates prevailed and sun-spots like those of the present day occurred during former periods. The petrified wood from the Pennsylvanian rocks generally shows no growth rings, leading some geologists to believe that the climate of that period was uniformly mild without cold seasons, although others state that the types of plants composing the coal flora would not develop growth rings even with a seasonal climate.

DEPOSITIONAL RHYTHMS

Varves

Varves are pairs of laminations differing from each other in color and texture, and thought to have accumulated during one year. They were first observed[10] in lake clays associated with glacial deposits in Sweden and Finland and consist normally of a lighter colored, more sandy bed and a darker colored, more clayey layer. Each pair of laminae was interpreted as a single year's deposit formed in a lake fed by glacial melt waters. The coarser textured, lighter colored layer is the summer and the finer, darker colored layer is the winter deposit.

Varves range in thickness from less than 1 millimeter to more than 1 foot. They were correlated from one exposure to another by the distribution of abnormally thin or thick single varves or groups. A correlation with successive positions of the ice front was found possible and the varves were found to thicken and to be composed of coarser material nearer the position of the ice margin. Johnston[11] carried on a study of recent sediments in Lake Louise, Canada, a lake fed by glacial waters. He discovered that the

[8] Huntington, E., The climatic factor as illustrated in arid America: Carnegie Inst. Wash., Publ. 192, pp. 95-157, 1914.

[9] Douglass, A. E., Climatic cycles and tree growth; a study of the annual rings of trees in relation to climate and solar activity: Carnegie Inst. Wash., Publ. 289, vol. II, 1928.

[10] Geer, Gerard de., A geochronology of the last 12,000 years: Comptes rendus, Cong. geol. intern., sess. 11 (1910), pp. 241-253, 1912.

[11] Johnston, W. A., Sedimentation in Lake Louise, Alberta, Canada: Am. Jour. Sci., 5th ser., vol. 4, pp. 376-386, 1922.

sediments exhibit paired laminations except in the delta where the glacial stream enters the lake. Calculations based on the known discharge of water into the lake, the volume of lake water, and the average amount of suspended sediment showed that the paired laminations are of the right order of thickness to be considered annual accumulations. In Sweden postglacial varves were discovered in sediments deposited in a lake which was drained in the 18th century. It proved possible to correlate these postglacial varves with late glacial varves and to reconstruct and date the history of the glacial recession northward across Sweden by means of the varves. Antevs[12] and others have attempted to correlate varve sequences between the Scandinavian countries and North America, but the tentative correlations made have been challenged on several grounds. Antevs[13] worked out varve sequences in the Connecticut River valley, upon which he based a chronology of ice recession in that area, indicating an average retreat of 1 mile in about 10 years. Flint[14] has studied the Connecticut valley glacial records and believes the glacier did not retreat, but became a stagnant mass of ice and that the varves were formed in a series of lakes at progressively lower levels, held in by temporary ice barriers. He does not accept the varves of that region as a basis for chronology. Andersen[15] has similarly criticized de Geer's conclusions in Denmark and suggested that the varves may record day and night, rather than annual rhythms. This controversy has not yet been settled to the satisfaction of all concerned. Sayles[16], Coleman[17], and others have discovered varve-like sediments associated with deposits formed during earlier glacial periods, now indurated and altered to banded shales and slates. These have been found in connection with late Paleozoic glacial deposits in South America, South Africa, Asia, Australia, and Massachusetts, and in connection with pre-Cambrian glacial deposits in Canada and elsewhere. Glacial varves are generally considered annual deposits and valuable for recording chronology and calculating rates of sedimentation.

Non-glacial Varves

Workers engaged in studies of recent and ancient lake sedimentation outside glacial regions have discovered various conditions in lakes which may be responsible for annual paired laminations or varves. Kindle[18] has noted that lake water becomes thermally stratified during the summer months, the warm light water (epilimnion) overlying colder and heavier water (hypolimnion). Fine muds and debris from aquatic vegetation will not sink through the denser water, but remain suspended until the fall overturn when all the water achieves an uniform temperature before freezing. This fall overturn is responsible for the settling of fine debris which may form a lamina overlying a coarser band deposited during the summer.

Bradley,[19] in studying the Green River oil-shales of Utah and Colorado, discovered paired laminations ranging from 0.05 to 0.2 millimeters thick and generally consisting of a band of dark clay very rich in organic matter and a lighter band with less organic matter, but in some parts of the shale particularly rich in calcium carbonate. Considering the area of the ancient

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[12] Antevs, E., Probable correlation between the last ice retreat in North America and in Europe (abstr.): Geol. Soc. Amer., Bull., vol. 36, pp. 153-154, 1925.
——— The last glaciation, with special reference to the ice retreat in northeastern North America: Am. Geog. Soc., Research ser. No. 17, 1928.

[13] Antevs, E., The recession of the last ice sheet in New England: Am. Geog. Soc., Research ser. No. 11, 1922.

[14] Flint, R. F., The stagnation and dissipation of the last ice sheet: Geog. Rev., vol. 19, pp. 256-289, 1929.
——— The glacial geology of Connecticut, Conn. State Geol. and Nat. Hist. Surv., Bull. 47, 1930.

[15] Andersen, S. A., The waning of the last continental glacier in Denmark as illustrated by varved clay and eskers: Jour. Geol., vol. 39, pp. 609-624, 1931.

[16] Sayles, R. W., Seasonal deposition in aqueoglacial sediments: Mus. Comp. Zool. (Harvard Univ.), vol. 47, pp. 5-63, 1919.

[17] Coleman, A. P., Ice ages, recent and ancient, pp. 234-236, 1929.

[18] Kindle, E., The role of thermal stratification in lacustrine sedimentation: Proc. Royal Soc., Canada, Trans., 3rd ser., vol. 21, pp. 1-35, 1927.

[19] Bradley, W. H., The varves and climate of the Green River epoch: U. S. Geol. Surv., Prof. Paper 158, pp. 87-110, 1929.

lake in which the shale accumulated and the probable quantity of suspended load introduced into it, Bradley concluded that the thickness of the varves was reasonable for annual deposits. He argued that organic matter, which is seasonal in production, should be concentrated in part of the annual varve, and that calcium carbonate would be precipitated in greater quantity in the summer than in the winter because of the evaporation of carbon dioxide from the water during the warmer season. Bradley decided there were about 3,000,000 varves in the Green River shale, and found that they displayed long period rhythms in alternations between organic rich oil-shales and marlstones. There are about 22,000 varves in each of these rhythms, and as this corresponds with the cycle of precession of the equinoxes he interpreted the rhythm as of that origin.

Stamp[20] described varved sediments from the Tertiary of Burma. He stated that the sediments were accumulated in the sea into which the ancestor of the Irrawaddy River discharged and that one lamina corresponds with the flood season of the river and the other with the low-water season. He found that there were on the average about 5 varves per inch, indicating a total period of at least 2½ million years for the whole series of rocks which is about 12,000 feet thick.

Under favorable conditions a saline lake undergoing evaporation may deposit a lamina of gypsum or anhydrite during one season and some other saline during another. Gypsum and salt alternations have been described from the Permian of Kansas, and anhydrite and dolomite varves of very regular development from the Permian of Texas, in a drill core.[21]

The speaker has observed presumably nonglacial varves in a fine-grained sandstone or siltstone of Carboniferous age in Wyoming, in which pure white laminae alternate with reddish laminae of somewhat finer texture. A fine-grained siltstone occurring near the base of the Pennsylvanian system and quarried for whetstones in Orange County, Indiana, is also regularly laminated or varved. The laminations in this formation seem to record numerous short-period rhythms which may be associated with sun-spot cycles.

LARGER RHYTHMS OR CYCLES IN SEDIMENTATION

Newberry[22] described a "circle" of sedimentation as consisting of sandstone at the base, followed successively by shale and limestone and separated from other "circles" by unconformities. He interpreted the "circles" as being initiated by diastrophic movement, following which coarse sediment was carried into nearby depositional basins. As the elevated land mass became worn down the particles transported to the basin became finer and deposition proceeded less rapidly. Eventually erosion of the source area ceased and limestone followed shale in the basin. The "circle" is terminated by renewed uplift, which again brings a supply of coarser sediment into the basin. This is a succession of events rather similar to the ideal concept of a geologic period, which should be initiated and terminated by uplift but otherwise marked by general stability.

In a valuable contribution to the literature on rhythmic sedimentation Barrell[23] outlined a sequence of events including periodic downwarping of basin areas with reference to a hinge line, and intervening periods when, without deformation, the basins became filled with sediment. He noted that because the downwarping would be greatest farthest from the hinge line, numerous stratigraphic units of the deeper part of the basin should wedge out against the edge of the basin or hinge line.

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[20] Stamp, L. D., Seasonal rhythm in the Tertiary sediments of Burma: Geol. Mag., vol. 62, pp. 515-528, 1925.

[21] Udden, J. A., Laminated anhydrite in Texas. Geol. Soc. Amer., Bull., vol. 35, pp. 347-354, 1924.

[22] Newberry, J. S., Circles of deposition in American sedimentary rocks, Am. Assoc. Adv. Sci., Proc. 22, pt. 2, pp. 185-196, 1874.

[23] Barrell, J., Rhythms and the measurement of geologic time: Geol. Soc. Amer., Bull., vol. 28, pp. 745-809, 1917.

Stamp[24] has described cyclic sediments of Eocene age in the London and Paris basins, which consist of successive groups of marine strata in one direction intertonguing with nonmarine strata in the other direction.

CARBONIFEROUS CYCLES OF SEDIMENTATION

The latter part of the Paleozoic era, consisting of the later Mississippian, the whole Pennsylvanian, and the early Permian periods, seems to have been characterized by some form of rhythmic sedimentation over many parts of the world. These rhythms represent a time interval much less than a geologic period, as the later Mississippian (Chester series) of the Mississippi valley includes 9 rhythms, the Pennsylvanian 30 or more, and the early Permian (Big Blue series)[25] of Kansas about 10. Born[26] in describing the upper Carboniferous (Pennsylvanian) of the Upper Silesian basin stated that 477 cycles have been found in that region. American Pennsylvanian cycles were first noted by Udden[27] in the Peoria quadrangle, Illinois, where a similar series of beds was found associated with coals 5, 6, and 7, and the Lonsdale limestone. Cyclic sedimentation was the subject of later investigation by J. M. Weller in Illinois and adjacent states.[28] Somewhat similar rhythms of the same age have been described from Ohio,[29] West Virginia,[30] Kansas and Nebraska,[31] England,[32] and the Donetz coal basin of Russia.[33] The speaker has also observed sedimentary rhythms in the Pennsylvanian rocks of Kentucky, Indiana, Iowa, Missouri, Oklahoma, and several states in the Rocky Mountains. The phenomenon thus seems very widespread in the northern hemisphere, though it has not yet been recognized in the southern hemisphere.

Weller stated that the cycle of sedimentation of the Pennsylvanian of Illinois when fully developed consists of the following lithologic units:

10. Gray shale with ironstone concretions
9. Marine limestone
8. Carbonaceous (black) shale
7. Marine limestone (local)
6. Gray shale with plant remains (local)
5. Coal
4. Underclay
3. Fresh water limestone
2. Shale or sandy shale
1. Sandstone

Erosional unconformity above No. 10 of next cycle below

Weller[34] proposed the name cyclothem for this group of strata and considered it to be approximately equivalent to a geologic formation. Beds 7-10

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[24] Stamp, L. D., On cyles of sedimentation in the Eocene strata of the Anglo-Franco-Belgian Basin: Geol. Mag., vol. 58, pp. 108-114, 194-200, 1922.

[25] Jewett, J. M., Evidence of cyclic sedimentation in Kansas during the Permian period, Kans. Acad. Sci., Tr., vol. 36, pp. 137-140, 1933.

[26] Born, A., Periodizitat epirogener Krustenbewegungen: XVI Intern. geol. congr., Rept., vol. 1, p. 172, 1936.

[27] Udden, J. A., Geology and mineral resources of the Peoria quadrangle, Illinois: U. S. Geol. Surv., Bull. 506, pp. 47-50, 1912.

[28] Weller, J. M., Cyclic sedimentation in the Pennsylvanian and its significance: Jour. Geol., vol. 38, pp. 97-135, 1930.

——— The conception of cyclical sedimentation during the Pennsylvanian period: Ill. State Geol. Surv., Bull. 60, pp. 163-177, 1931.

[29] Stout, W., Pennsylvanian cycles in Ohio: Ill. State Geol. Surv., Bull. 60, pp. 195-216, 1931.

[30] Reger, D. B., Pennsylvanian cycles in West Virginia: Ill. State Geol. Surv., Bull. 60, pp. 217-239, 1931.

[31] Moore, R. C., Pennsylvanian cycles in the northern mid-continent region: Ill. State Geol. Surv., Bull. 60, pp. 247-257, 1931.

[32] Hudson, R. G., On the rhythmic succession of the Yoredale series in Wensleydale: Yorkshire Geol. Soc., Pr., vol. 20, pt. I, pp. 1-11, 1923-24.

[33] Grabau, A. W., The Permian of Mongolia: Am. Mus. Nat. Hist., Natural History of Central Asia, vol. 4, pp. 432-442, 1931.

[34] Wanless, H. R., and Weller, J. M., Correlation and extent of Pennsylvanian cyclothems: Geol. Soc. Amer., Bull., vol. 43, p. 1003, 1932.

of the cyclothem are considered marine in origin as they generally contain marine fossils. Beds 1-6 are considered nonmarine, largely because they contain traces of land or fresh water plants or animals, and because marine fossils are not found. The successive cyclothems are not all composed of the full sequence of beds. As one cyclothem is traced over a large territory certain members may be found to disappear or other new members may be introduced. In some regions, like southern Illinois, eastern Kentucky, and Virginia, the cyclothems consist almost wholly of non-marine members, while in other regions such as in the upper Pennsylvanian of northern Illinois, Kansas, and Nebraska, the non-marine beds of the cycle may be greatly reduced in thickness or entirely absent, making the record largely one of marine sedimentation. Traced into other regions the sedimentary rhythms include coarse conglomerates, as in central Colorado and Virginia; red beds, as in the upper Pennsylvanian of Ohio, West Virginia, and Oklahoma; chert or flint, as in the lower Permian of Kansas; and gypsum as in Kansas and Colorado. The lithologic composition and thickness of the cyclothem is a record of (1) the proximity of the area to highlands providing sedimentary materials, (2) the rate of subsistence, (3) the average elevation of the locality in respect to sea-level, and (4) the climate, both of the source area of the sediment and the depositional basin. Geosynclinal areas marked by rapid subsistence have a thicker rhythmic record than regions with less rapid subsistence and if they were close to old land masses, as the Appalachian geosyncline was, they include coarser sediments. During the Pennsylvanian period, the eastern United States evidently had, as it has now, a more humid climate than the Rocky Mountain region. This is indicated by more numerous and thicker coals, more abundant horizons yielding fossil plant impressions, and a predominance of shales, the product of deep chemical weathering of the lands providing sedimentary particles. In contrast the cyclothems of the Rocky Mountain region contain very few coals or plant horizons, the sandstones and conglomerates contain abundant feldspars and other unstable mineral species, shales are infrequent and wholly lacking in some areas, red beds are common, and gypsum and salt are found in a few places. The tracing of a particular cyclothem from the Appalachian region to the Rocky Mountains with a study of the varied conditions of sedimentation would provide a significant picture of conditions of regional climate and physiography of the Carboniferous.

Moore[36] has described a still more complex rhythm from the upper Pennsylvanian of Kansas, to which he has applied the name megacycle. This includes as many as 5 marine limestones and locally as many as three coals. Each limestone or shale of the megacycle is characterized by some textural, structural, or faunal features resembling those of corresponding shales or limestones in other megacycles but differing from others in the same megacycle. A critical analysis of the upper Pennsylvanian succession in southern and central Illinois suggests the presence of a corresponding complex rhythm, characterized by more shale, coal, and sandstone and less limestone than in Kansas.

INTERPRETATIONS

Several students of Carboniferous cyclic sedimentation have suggested explanations for the rhythmic changes involved. Stout[38] and Cady [37] have postulated a broad interior basin subject to periodic downwarping during which shales, limestones, and sandstones were deposited and ultimately built up to a profile of equilibrium on which coal swamps established themselves, to persist until a renewal of downwarping. Stout attaches little significance

[36] Moore, R. C., Stratigraphic classification of the Pennsylvanian rocks of Kansas: State Geol. Surv. of Kans., Bull. 22, pp. 29-35, 1936.

[38] Stout, W., Pennsylvanian cycles in Ohio: Ill. State Geol. Surv., Bull. 60, pp. 204-205, 1931.

[37] Cady, G. H., Alternative interpretation of the subdivision of the Pennsylvanian series in the Eastern Interior province (abstract): Geol. Soc. Amer., Proc. for 1933, p. 71, 1934.

to the breaks at the bases of numerous sandstones and believes the sandstones to be marine. Weller,[38] on the other hand, believes that the surfaces below the sandstone were the result of erosion above sea-level and that the sandstones are non-marine deposits. In order to fit these views into the interpretation of the rhythmic movements Weller postulated cycles of alternating elevation and subsidence for the interior of the United States, the subsidence exceeding the elevation in amount. The maximum emergence in each cycle is placed at the erosional surface initiating the rhythm and the maximum subsidence at the deposition of the upper marine limestone (member 9). Born[39] interpreted the Carboniferous cycles of Europe as due to accumulation of stresses to the breaking point, when they were relieved by movement. He believes the movements of similar sorts occurred at similar intervals, and compared the procedure with "breathing" of the earth. The speaker, with Professor F. P. Shepard[40] suggested that the movements of the depositional basin were dominantly downward, but that the sea-level repeatedly rose and fell, causing frequent wide migrations of the strand-line. The sea-level fluctuations were tentatively interpreted as due to the alternative growth and wastage of late Paleozoic continental glaciers principally in the southern hemisphere. They suggested that climatic cycles related to the precession of the equinoxes or some other extra-terrestrial cause might be responsible for the growth and melting of the glaciers and for changes in conditions of sedimentation outside glaciated areas. Critics of this latter view point out that late Paleozoic glaciation is not definitely known to coincide in time with the Carboniferous cyclic sedimentation, nor is it known that there were as many glacial epochs as there were cycles. The length of time required for the individual Carboniferous rhythms has not been determined, nor is it known whether all are of approximately the same duration. The great similarity in sequence in numerous successive cyclothems and their approximate equivalence in thickness suggests that they record approximately equal periods of time and the operation of some regular rhythmic forces.

Rhythmic and Nonrhythmic Periods of Earth History

In contrast with the Pennsylvanian and Pleistocene periods during which there were frequent changes in climate, sea level, and types of sedimentary rocks, other portions of the geologic time scale seem to have been characterized by the persistence of similar conditions for long periods of time. The middle Ordovician, the middle Silurian, and the middle Mississippian periods were characterized by continuous limestone or dolomite deposition throughout the central parts of the United States. There were thus intervals of geologic history when earth movements and climatic changes attained a rather regular periodicity recording itself in erosion cycles, cycles of sedimentation, and glacial and interglacial epochs. There were other somewhat longer intervals when periodic earth movements and climatic changes apparently were subdued or lacking.

[38] Weller, J. M., Cyclical sedimentation in the Pennsylvanian and its significance: Jour. Geol., vol. 38, pp. 110-135, 1930.

[39] Born, A., Periodizitat epirogener Krustenbewegungen: XVI Intern. geol. Congr., Rept., vol. 1, pp. 169-189, 1936.

[40] Wanless, H. R., and Shepard, F. P., Sea level and climatic changes related to late Paleozoic cycles: Geol. Soc. Amer., Bull., vol. 47, pp. 1177-1206, 1936.

Our Exhaustible Resources of Minerals—What Should Be the Aims of a Conservation Program?

Morris M. Leighton

Chief, Illinois State Geological Survey, Urbana

SCIENTISTS, as a professional group, have emphasized the importance of conservation of our natural resources along ethical lines more than any other group of our people. And there are reasons why they should. They do not believe in wasteful exploitation; they appreciate the place which natural resources play in the role of progressive human society; they are as devoid of ulterior motives and selfishness as any group; they possess a larger knowledge of the limitations of the natural resources with respect to requirements of future generations than most lay groups; and they have become liberated from the old view that the life of man on this earth is likely to be cut short at an early date. Furthermore, they have a passion for progress and a realization of the rights of unborn generations.

With respect to conservation, astronomy teaches limitless time, physics the relatively unlimited sources of solar energy, chemistry the universality of the physical and chemical changes, geology the long future of habitability of our globe, and biology the probable and relatively endless chain of generations of the human species, at least so far as a long future is concerned. All of these sciences furthermore teach that we of the present are writing a tremendous draft upon the resources which future society will also require.

On the other hand, the average layman and the average business man deals primarily with the realities of the present generation. A future of a few centuries is a tremendously long time to him, a million years is hardly a reality to him, he still thinks in terms of the possibility or probability of vast resources yet to be discovered, he is quite naturally concerned with the problems of operating at a profit in the exploitation of the natural resources rather than with the problems of existence which will face generations of mankind in the remote future, and he faces daily the changing forces of competition which continually threaten to put him out of the running.

It is therefore not surprising that there should be these differences in points of view between the scientists and the laymen.

Yet, notwithstanding these different points of view there has developed a wide and increased interest in the subject of conservation and a greater recognition of its importance. However, we must realize that the *modus operandi* by which progress in conservation may be accomplished is and must be inevitably slow, by reason of the imperfection of our knowledge as to how best to use our natural resources. This fact places a heavy responsibility upon all of the sciences, because their contribution must be something more than the mere teaching that conservation is a necessity.

Historically the conservation movement in America had its inception in the rapid depletion of the forests and in the consideration of certain factors which must be taken into account in the development of our streams. The disappearance of the forests could be seen by everyone, and the problem of the changing regimen of our streams, brought about by the widespread destruction of the natural vegetal covering and the plowing of the soil, was apparent to engineers and statesmen who had given the matter study. As the industrial revolution got under way, following the Civil War, and increasing quantities of iron ore, coal, copper and other minerals were extracted, it became more and more apparent that vast inroads would soon be made on the exhaustible resources of the nation. It, therefore, came to be realized that this country was facing a grave national problem. This led President Theodore Roosevelt to call a conference of the Governors of the forty-eight states in 1908.

Although the motives for the call were most worthy, the results were not entirely satisfactory. Anyone who reads the minutes of that conference and the addresses that were made cannot help but feel that too much stress was laid on the wastefulness and the exploitation methods of private industry and too little recognition given the conditions which, to a certain degree, justified the methods at that time in this country's development.

This was in part remedied rather late in the conference, in an address made by our revered former President of the University of Illinois, Dr. Edmund J. James, at the fourth session. His point of view is worthy of our careful consideration, and I therefore quote extracts at some length.

> There is no doubt that we have been extremely wasteful in our mining processes, taken as a whole, and it is high time we should direct public attention to the necessity of greater efficiency in our methods of mining than has characterized our operations thus far. But after all, the determination of what is the proper mining policy turns essentially upon economic considerations. Economic exploitation of our mining resources does not consist in making the utmost possible saving in the narrow sense of the term. It would, for instance, be perhaps entirely feasible in the mining of coal or iron to extract 90% or 95% of the coal or iron from the mines which are open, and yet such a policy might be after all uneconomic. In other words, it would probably cost more than the entire coal is worth to extract from the mines 99% of the coal to be found in them. It would probably cost quite as much as the gold and silver and iron are worth to undertake to extract 99% of the metals to be found in the mines. That is to say, the extraction of all the valuable material would be such an expensive proceeding as to make mining itself unprofitable. This, of course, would be uneconomic in the highest degree. The question, therefore, as to what the best mining policy is must turn at bottom upon the fundamental question as to what method will, everything considered, turn out the highest possible value.
>
> It would be quite feasible, therefore, though I should think there is very little probability of such a state of things, to adopt a set of mining laws which would hamper the development of the mining industry to an entirely unreasonable extent, as I am quite sure some of the mining codes of other countries have done.
>
> There is no doubt that we have exploited our farms and our lands in many parts of the country in a very wasteful way; that we have exploited our soils in some cases to such an extent as almost to destroy them and to make it impossible to restore them except by a very large expenditure, if at all. . . .
>
> But economics students would insist that the fact that certain farms in the United States have passed out of cultivation does not of itself prove that the agriculture policy of the Nation has in the large been a mistaken one. . . . Many farms in New England and New York and some parts of Pennsylvania and Virginia have in the last two generations fallen out of cultivation. This fact in itself does not necessarily prove that the agricultural policy of the State or Nation has been bad. On the contrary the fact that those unproductive farms fell out of cultivation was in many instances a sign of one of the greatest blessings that ever came to the American people, namely, the possession and opening up of magnificent opportunities in the Mississippi valley and the West. . . . Those farms fell out of cultivation not because they were exhausted, for in many instances they produced more than when they were first cultivated, nor because we can not cultivate them today as well as we could cultivate them when they were first put under the plow, if we were only willing to accept the return which they would bring us; but because the standard of life among the American people has advanced to a point where the methods of the cultivation of the 1850's applied to those farms will not yield us that with which we are or should be content.

Thus, it should be emphasized that the economics of the situation must be given a fundamental place in considering any program to accomplish conservation.

Conservation of Minerals

We are concerned in this paper with the question of the conservation of exhaustible mineral resources, primarily those of Illinois.

In this State, as in most states, the mineral resources belong to individuals or companies or corporations. The theory of our constitution and of our laws, we infer, is that they, like the farm lands, are for private use or exchange. If they occur under conditions such that they enhance materially the value of the land, they are taxed along with the land. Legislation affecting their recovery concerns primarily human safety and to a small degree their preservation from damage, as in the case of oil-well drilling through coal beds.

The amount of capital invested in their recovery, preparation for the market and for means of distribution by railway and motor truck, represents hundreds of millions of dollars. Industries have arisen which provide employment for many thousands of men. Communities have been built up around them. The ability of the companies to fill contracts for large orders has brought other industries to the State. In these and other ways, the mineral industries of Illinois have become indispensably an important part of the framework of society.

What is the status of their conservation?

In a paper of this scope it is not possible to review all of the mineral resources of Illinois with respect to the status of their conservation; we shall be limited to one of them, and only the broader features of that one, and from it develop our thought as to what a conservation program should entail.

We shall consider coal, that mineral being our most valuable mineral resource. In shaft mining, in the Northern Illinois field, the Longwall system is used and about 95 per cent of the coal is recovered, whereas in the rest of the State the room-and-pillar system is used and the average is about 50 per cent. By far the larger percentage of coal mined in the State is by the room-and-pillar system. The reason why the room-and-pillar system is used, although the percentage of recovery is only one-half, are in the last analysis purely economic. Where the coal beds are thick and other conditions are such that "back filling" cannot be employed to prevent subsidence that will alter the surface drainage of level agricultural lands or damage surface structures, pillars of coal of adequate size must be left. Damage to farm lands is a controlling factor in Illinois. Unequal subsidence may create swampy places or disturb drainage systems or damage water wells. This invites damage suits asking for extravagant awards. This, and other uncertainties, deter attempts at pillar recovery. Outright purchase of both surface and underground rights prevents insuperable obstacles in many cases, but where this is done there are usually other tracts intercheckered with these so that no relief can be obtained. Moderately hilly areas offer their problems also if the subsidence cannot be controlled to keep from interfering with streams and surface structures.

Coal losses, however, include other than that left in pillars. In places coal is left in the roof and on the bottom, especially if it is very high in ash or if needed to serve special purposes. Coal must also be left under railroads, along boundaries, or to prevent flooding from water in abandoned workings at a higher elevation. Much coal is also lost through premature abandonment of mines. In many cases such pieces of virgin coal are so irregular and small as to make the cost of future reopening prohibitive. Such premature abandonment took place on a considerable scale during the 20's and early 30's of this century when depression conditions caused many companies to become bankrupt. Coal is also lost where there are rolls or where the coal bed becomes too dirty or too thin to work under present economic conditions.

From the foregoing and other facts it is apparent that the problem of conservation is exceedingly complex. These complexities become even greater when it is realized that competitive conditions are such that small additional

costs would endanger or effect bankruptcy, and as has just been pointed out, bankruptcy in many instances brings waste from premature abandonment of irregular areas of virgin coal, and it also has its serious effects upon employment and general economic conditions.

Since about 1920 the market for coal has ceased to grow, generally speaking, due to competition of other fuels and energy resources.

Strip mining results in recoveries closely approximating 100 per cent, but in this case the soil resources are destroyed. This raises the question of competition in conservation, another angle of the already complicated problem. Strip mining also sacrifices employment opportunities because of its highly developed state of mechanization. Thus there are arguments on both sides, but again we are reminded that the task of outlining or shaping a program of conservation is not as easy as the great majority of our people might think.

Losses which are unavoidable must be charged against the conditions under which we are operating. These conditions are either economic or technological. While advances in technology have been rapid, relatively speaking, we have a long way yet to go before we shall have the scientific and technologic information necessary for an adequate conservation program. Many of the so-called wasteful practices in the production of coal, as in the production of many other commodities, have been necessary for the industrial development of the State, and for the progress in the standards of living which we all share. We cannot afford, therefore, to be radical in the changes that we wish to bring about for there is danger of disaster for both the financial and social well-being of the entire State.

It is also well, before we embarrass ourselves with making unjust criticisms, to recognize that incomplete recovery is less sinful than wasteful utilization. After the coal is delivered to us for our use, how many of us use it efficiently? We burn only a portion of it and send the rest up the chimney. We conserve only a part of the heat and let the rest pass through our uninsulated walls and ill-constructed windows and doors. In the power industry, in the use of railroad fuel, and in blast furnaces, we have advanced, but much remains to be done.

Again, we shall be criticised for such waste by future generations, unless they liberally charge it against the incomplete state of our knowledge.

Where then, and how, shall we attack this problem of conservation of our coal resources?

Let us be exceedingly cautious about legislating ourselves into a solution, except where it is patent that legislation has a place. Instead let there be an insistence on improvement in our technical knowledge by thorough-going researches and practical demonstrations of the findings. First of all it is necessary to pursue investigations in regard to the geological conditions that must be met in economic mining; second, there must be further experimental study in the technology of mining; third, there must be a thorough study of the constitution of the coal-beds in order that progressive steps can be taken in the proper preparation of the fuels for their different uses; fourth, researches must be carried on to perfect the use of coal; and fifth, studies must be made of the economic conditions of the markets, in order that abnormal situations may be recognized; and sixth, the ready dissemination of new knowledge should be facilitated.

The policy of increasing our knowledge will lay the proper foundations for policies of conservation, and will react beneficially to sound economic and social conditions. The same principle is fundamental with respect to our other exhaustible natural resources, the discussion of which is impracticable here within the limits of time available.

Increase in knowledge will be an important compensating factor to award to our descendants for the depletion of natural resources which they will inherit. As two of our authorities on the economics of mineral resources have stated: " . . . if science shall make a revolutionary discovery, if man shall unlock the secrets of photosynthesis and atomic energy, our population may then be trusted to increase to the point at which it can make full use of the new stores of power."[1]

[1] F. G. Tryon and Lida Mann, Mineral Resources for Future Populations, Pollak Foundation for Economic Research, Newton 58, Massachusetts.

Advances in the Renewable Natural Resources Program of Illinois

Theodore H. Frison

Chief, Illinois State Natural History Survey, Urbana

MY participation in this program today, speaking on the subject, "Advances in the Renewable Natural Resources Program of Illinois," brings to mind two previous papers presented on annual programs of the Illinois State Academy of Science and later published as a part of the Transactions.

Early attitude toward natural resources.—The first of these papers was presented by S. A. Forbes at the Bloomington meeting in 1912 and its title was "The Native Animal Resources of the State." This paper sketched a broad, general picture of the abundance of the native animal life of Illinois when the state was occupied by the Indians, and the subsequent reduction of these particular resources in the wake of its rapid settlement by white men. The philosophy of the 1912 period is fairly well revealed by a quotation from this article, as follows: "The whole process has evidently been a perfectly natural and inevitable one—as much so as the flood of the tide in the wake of the revolving moon—and immensely advantageous also from every point of view except that of the inadequate, incompetent and ill-adapted population which it has reduced or suppressed." A militant progressive conservation program, aimed to check further reductions of our renewable native natural resources and to increase certain desirable ones was, as yet, unprojected. Glimmerings of the future, however, were indicated in this paper by the demand expressed for "prompt, vigorous and intelligent rectification and control" of pollution of waters, particularly the Illinois River, which was then showing the effects of the opening of the Chicago Drainage Canal, and in another paragraph by a plea for this Academy to promote by resolution the passage of the National Migratory Bird Act.

Modern attitude toward natural resources.—The second paper I wish to mention is one it was my privilege to present on a symposium on "Conservation of Illinois Agricultural and Human Resources" at the time of the Decatur meeting of this Academy in 1934. This essay was entitled "Utilization of Illinois Lands for Forestry, Wildlife and Recreation." I cite this latter paper because its content reveals a marked turning point in the attitude of scientists and the general public in the approach to the renewable native natural resources problems of Illinois. Realization had come that the depletion of such resources had gone too far for the public good in many instances, and a definite program was beginning to take shape for preserving and, if possible, increasing what was left of certain desirable resources of this kind. In this paper there was (1) a facing of the fact that, while restrictive legislation can perhaps retard the decline of certain renewable and highly desirable natural resources, it does not necessarily increase them or even insure their preservation; (2) the recognition that, regardless of the value and desirability of some fish hatcheries and game farms, such a program, because of the costs involved, offers in our State no sure-fire panacea for a general increase of valuable fish and game resources; and (3) the start of a delineation of a sound land utilization program for Illinois in regard to forestry, wildlife and recreation. Four years have gone by since 1934 and during this period definite advances in harmony with this 1934 conservation program have been made. These advances, when we stand close to them in time and space, may seem slight, but, judged from the philosophy of 1912, they are epochal steps.

No single unit of government or group of people is entirely responsible or can take all the credit for this rapidly-advancing program. In spite of its diversity, in origin and administration the pattern of this program is clearly definable and fortunately its different elements are most compatible. It is my belief that the very diversity of the organizations participating in this youthful program is a guarantee that it will have better balance and perspective. We have not reached as yet such perfection in planning for the infinite preservation and increase in renewable natural resources that as a nation or state we can afford to put all of our plans in one brief case or follow one stereotyped procedure.

Natural resources defined.—I have mentioned our renewable natural resources several times thus far in this paper and perhaps I have already proceeded too far without defining the particular type of resources I am including or excluding under this phrase. By renewable natural resources I have reference to the living flora and fauna, particularly those of demonstrable economic importance, of this State. To the average citizen this implies forest and wildlife resources. Wildlife resources include, of course, our fish, bird and mammal populations, and forest is to be broadly interpreted as applying to plant life, in general. The fundamental difference between a conservation program dealing with non-renewable natural resources, such as was the subject of the preceding speaker's address, and a program for renewable natural resources is that the non-renewable cannot be cropped successively without reducing the total resources of that kind, whereas in many instances the renewable resources, with proper management, can be cropped successively without reducing the total resource, and under certain conditions such resources can, moreover, be increased. To prevent getting too far afield, my definition of renewable natural resources for today's purpose must be further restricted to exclude those renewable natural resources which have already definitely reached such a place in management and development that they are generally considered as agricultural crops.

BACKGROUND OF THE PROGRAM

Every story and play has a background or foundation and so does a renewable natural resources program for Illinois. Fortunately, due to many years of effort by investigators and scientists of varied stripe and hue, this background is not fictitious but real. A long and detailed description of this State is not necessary before such an audience as this. It does seem necessary, however, to point out that the location of Illinois, in the heart of a large land area, and its extent, a distance of almost 400 miles from north to south, about 285 miles from east to west, presents differences which must be considered in planning for a sound renewable natural resources program. The distance in miles from north to south in the latitude of Illinois is sufficient by itself to influence the composition of the flora and fauna without the aid of a great variation in elevations as proved by the existence within our borders of cypress swamps, mistletoe and cotton fields in extreme southern Illinois and the tamarack bogs of the northeastern counties. The general interior continental location of our State is sufficient also to make our lands a meeting place of eastern and western species of plants and animals, as well as those of northern and southern affinities. Here and there, too, all over the State there are diverse local ecologically different habitats such as the sandy areas near Havana, Kankakee and Savanna, the comparatively recent glacial lakes of Lake and McHenry Counties, the generally distributed large and small river systems, the areas originally with prairie or forest cover, and, in that part of the State in which we are today, a worn-down mountain range, frequently referred to as the Ozarkian Uplift.

Need for varied program.—Because of these differences, no blanket or single-track conservation program can be adopted for Illinois and produce the best results. The hunting season in the northern part of the state, if correctly timed for breeding seasons, rarely, if ever, would coincide with that in the southern tip. The migratory waterfowl which provide such extensive shooting at times in certain localities, particularly the Illinois River valley,

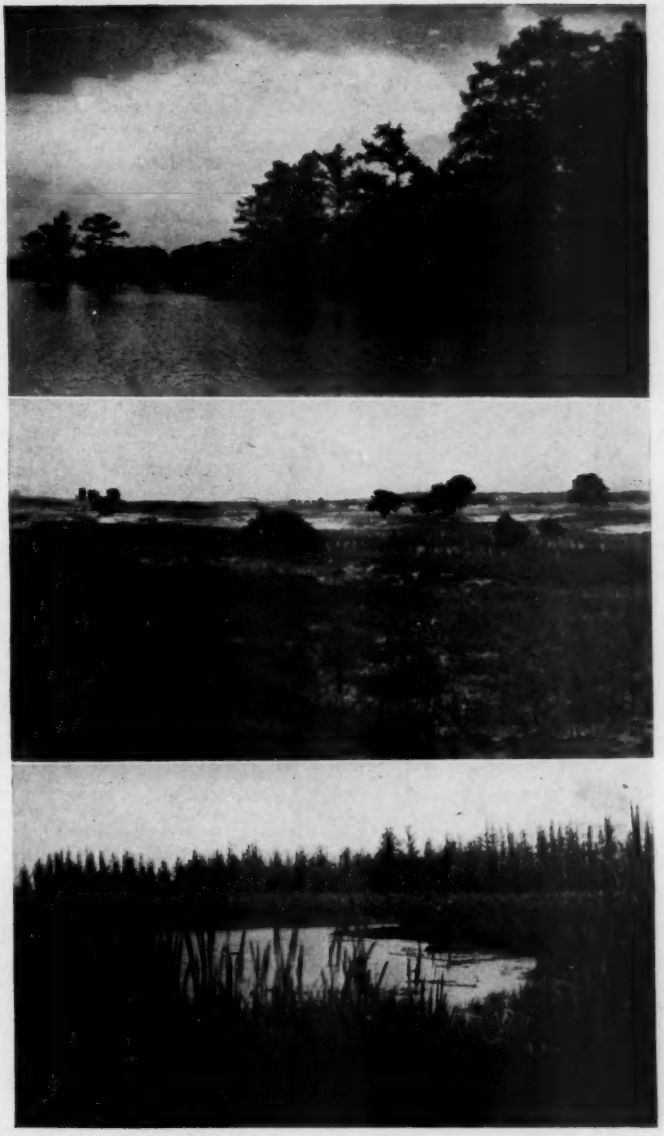


PLATE I.

Upper. Cypress stand along the edge of Horseshoe Lake in southern Illinois.
Middle. Sand dunes and flats near Savanna, in the northwestern part of the State.
Lower. Tamarack bog near Volo, in northeastern Illinois.

are mostly hatched far without our borders and are mainly visitors temporarily in our custody. The harmonizing of any sizeable upland game bird or fur-bearing mammal population on such valuable agricultural tracts as compose large areas in our state indeed presents a difficult problem. In a state endowed by nature with waters of very high relative productiveness of fishery resources, the problem of supplying adequate fishing for the many citizens of the state is made difficult by natural limitations in water area, and by most valuable agricultural and industrial industries which diminish aquatic plant and animal life through drainage activities, silting as a result of erosion of denuded soils, and pollution.

All of these statements mean, first that a renewable natural resources program in Illinois must be varied to suit the particular locality; secondly, that, because of high land values, a relatively low proportion of poor to good agricultural land and a large population, any area specifically dedicated to forestry and wildlife resources should be developed to its maximum state of usefulness; and lastly, that it is imperative that any such program be conceived and developed upon impartially- and scientifically-acquired data.

EXTENT OF RENEWABLE NATURAL RESOURCES

Now, what are the renewable natural resources of Illinois which should have special consideration in our state program and which should come within the scope of my topic, and what are the recent advances implied in the title of my paper? Obviously, since our state has a flora and fauna which contains some 2,800 different kinds of plants, 20,000 insects, 240 mollusks, 85 reptiles and amphibians, 170 fish, 365 birds and 54 mammals, I cannot go into any detail concerning many individual kinds or species. My remarks, therefore, are centered about such general groupings as forests, fish, game birds, and fur-bearers, all of which have very definite and tangible values.

The fact that forests, fish, game birds and fur-bearers are only now beginning to command the serious attention of the State may seem to imply that their economic values are negligble. This is not the case. These same resources were once practically the total support of the inhabitants of this region, furnishing food, clothing and shelter. This is certainly proof of their basic or fundamental values. Now that all the good soil areas of the state are under cultivation and the problem of providing for the necessities and leisure moments of a large population is beginning to bear down, these types of resources are coming to be looked upon with covetous eyes.

A couple of years ago the U. S. Junior Chamber of Commerce estimated that 13 million citizens of this country purchasing hunting and fishing licenses were spending annually about 750 million dollars in pursuit of their favorite recreation. In 1935, 267,606 hunting licenses and about 300,000 fishing licenses were issued in Illinois. Add to these figures the number of persons not required to buy licenses, because of hunting or fishing only on their own lands or because of being under age, and the importance of this industry when translated into dollars and cents begins to be revealed in its true light. Then, too, there is a much larger army of people interested in furthering and preserving these same resources purely because of their general enjoyment and appreciation of the out-of-doors.

The statement that my remarks concerning renewable natural resources are centered chiefly about such general groupings as forests, fish, game birds and fur-bearers should not be interpreted to mean that other forms of biological resources do not have definite beneficial or detrimental values. The chinch bug in 1934 reduced the collective income of the farmers of Illinois over 30 million dollars. The state program in this instance, however, is one of control associated with agricultural crops and by earlier definition is eliminated from discussion in my subject today. It does show, however, how important some other forms of our plant and animal life can be. All biological scientists, naturalists and conservationists know that birds in general exert a tremendous influence in holding in check many insects and that birds as a group are beneficial to man and should be preserved and the numbers of many kinds increased. The same may be said for many forms of animal life, including even the lowly and often needlessly destroyed

snakes. Other forms of life, both plant and animal, while of lesser importance economically, add much to the beauty, enjoyment and interest of our fields and woodlands, and thereby are of concern to all lovers of the out-of-doors. Fortunately, when our renewable natural resources program is planned so as to preserve and further the increase of our forests, fish, game birds and fur-bearers, most other forms of plant and animal life profit accordingly and all categories of conservationists, scientists, sportsmen and nature enthusiasts can support such a program.

Fig. 1.—Lifting nets in Maple Lake, located in the Forest Preserve District of Cook County. Through study of fish populations, the Natural History Survey is able to make recommendations to improve fish management of Illinois lakes.

Fish.—The value of our fisheries resources is easily underestimated because of the character of this particular industry. I have already mentioned the large army of fishermen. Based upon the actual water area of the state there is for each fisherman about one-half acre of water with a varied rating from zero to high productiveness. In 1908 the number of men employed in the fishing industry in Illinois, particularly in the Illinois River valley, was given in a census report as 4,359. That same year the Illinois River alone produced $721,000 worth of commercial fish, and over $350,000 worth of mussel shell products came from our rivers. In my Academy paper of 1934, already referred to, I stated as one of the points of a sound utilization program for Illinois the "restoration in the interest of fish, game, forestry and recreation to as natural or improved state as possible of much of the former floodplains and bottom land lakes of our river systems, particularly of the middle and lower Illinois River valley, and the impounding of new water areas wherever useful and practical. Clean waters are prerequisites to the fullest success of this program." This statement requires no modification now. The impounding of small scattered water areas in counties without good lakes and rivers is the only answer to increasing local fishing.

Forests.—The statement that the forests of a state are an economic asset requires no proof before such a gathering as this. There is a direct value

of the timber products such as logs, boards, boxes, implement handles, cord wood, mine props, railroad ties, etc., which reached a figure in 1920 of 88 million dollars. The forest products of farm woodlots alone in Illinois was evaluated in a 1935 census as a $4,500,000 industry. There is, in addition, the indirect value of timbered areas for the preventing of erosion in poor soil type areas and hence their value in reducing the silting of streams, for the harboring of valuable wildlife resources and for the recreational uses of such areas. All of these values are now becoming of importance equal to

Fig. 2.—An example of forested area in the Ozarkian uplift in the southern part of the State. Saddleback Ridge, near Wolf Lake.

or perhaps greater than the board foot values of timber. According to a forestry survey of the State made by the Natural History Survey, about 42 per cent of the State was originally forested. This 15 million acres of forest, with its average stand of 7,500 board feet per acre, had dwindled to about 3 million acres, with about 2,000 board feet per acre, in 1926. An ideal or theoretical forest area for Illinois, based upon soil types and a sound utilization program, calls for the restoration of about 6 million acres of forest, using for this purpose the land which is now forested, some which is now semi-cleared, and some which at the present time is practically waste land from any point of view.

Game birds.—Game birds cannot be sold upon the open market, except pheasants under game breeders laws, and, therefore, unlike timber products and certain fisheries and fur-bearer resources, no figures can be presented concerning their annual commercial value. The amount of money spent by sportsmen in quest of quail and migratory waterfowl is an astonishing sum, as indicated by the sale of 267,606 hunting licenses in Illinois in 1935 and 53,251 migratory waterfowl hunting stamps in 1937. The initial cost of licenses is small compared with the investments in numerous waterfowl hunting clubs, the renting of blind or shooting privileges, guide services, cost of guns and ammunition, travel, meals and lodging, and a large number of other incidentals considered a necessity by the average sportsman.

Quail, pheasants and migratory waterfowl such as mallards, blue-winged teal, pintails, Canada geese and a few others bear the brunt of game bird

hunting in Illinois. The quail is the principal game bird in southern and central Illinois. Along the river courses of the State, particularly the Illinois and Mississippi, is centered the greatest part of duck hunting. In extreme southern Illinois, not far from Carbondale, is the best goose shooting. In northern and north-central Illinois the introduced ring-necked pheasant provides considerable sport for hunters. A few other species of birds contribute to the hunter's bag but they are relatively unimportant in

Fig. 3.—Mallard drake alighting. The mallard is one of the principal varieties of migratory waterfowl frequenting Illinois waters. Photo by courtesy of Paul S. Smith.

comparison with quail, the ring-necked pheasant and various species of migratory waterfowl. Prairie chicken, a fine game bird and once abundant in the State, are on the protected list, and our present population of them would soon be decimated if a general open season on them were permitted. Good statistics are lacking concerning the numbers of game birds killed, but the U. S. Biological Survey reports that for the United States the average kill of ducks per season by purchasers of duck stamps is ten. This figure is undoubtedly low and it is safe to say that between 350,000 and 600,000 ducks are shot annually in Illinois, depending upon whether the season is bad or good and the season short or long.

Mammals.—Among the mammals, the cotton-tail rabbit affords the chief hunting, and the number killed in all parts of the State annually exceeds the total for any other species of game. Because of their comparative abundance, rabbits up until the 1937 hunting season were still sold on the open market. The year 1937 was considered a poor year in Illinois for rabbit shooting; nevertheless, sportsmen in such a highly-cultivated area as the vicinity of Decatur, in Macon County, reported an average kill of more than three for each time they went hunting. Other mammals which must be considered among our particularly valuable renewable natural resources are muskrats, opossums, raccoons, minks and squirrels. For several years our Natural History Survey has been assembling information regarding the income derived in Illinois from the trapping and hunting of fur-bearers, and from the sale of their pelts. Our data indicate an income, even though production is unaided by man, of one million to two million dollars a year. Of the furbearers responsible for this income, the muskrat is by far the most important and accounts for one-half of the total. The average catch of

muskrats per Illinois trapper reporting is about 30. The highest catch is in the marsh areas of Lake and McHenry counties where the average jumps to about 90 pelts per trapper. The lowest production of muskrat pelts is in southern Illinois and is explained by the absence of marshy areas and by unstable water levels.

Preserving and increasing natural resources.—The objectives of the renewable natural resources program for Illinois must definitely, then, provide for the preservation and, if possible, the increase of such valuable re-

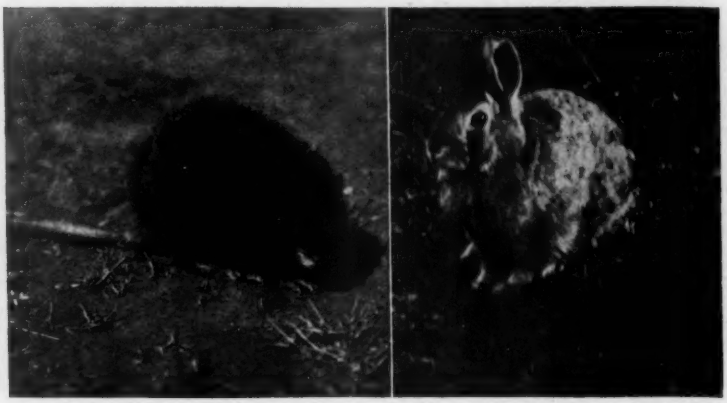


Fig. 4.—The muskrat (left) is by far the most important Illinois fur-bearer. The cotton-tail rabbit (right) is the most hunted of Illinois game.

sources as our fishes, game birds and fur-bearing mammals. Other wildlife resources will also profit by the same program. How is such a program to be advanced? The experience of past years indicates that legislation may help to retard declines of wildlife populations but does not necessarily increase such resources. Propagation of fish and game populations in sufficient numbers to supply the demand is not the answer because of the costs and other factors involved, however valuable or worth while for certain purposes some fish hatcheries and game farms may be. To preserve these resources and, better still, to increase them so that they are a direct economic asset, they must be provided with areas supplying sufficient food and cover to enable them to reproduce naturally. The "cropping" of such resources, increases permitting, should be in accordance with accurate information concerning minimum desirable population levels and changing cyclic fluctuations determined by impartial scientific investigations.

Thus far in this paper I have presented the general background and most important objectives of a renewable natural resources program for this State. In my remaining remarks I will outline those steps or actions which I consider as the most important and tangible recent advances in such a program.

RECENT ADVANCES

There is an old saying that while you watch the tea kettle it never boils and another one that at times one cannot see the forest for the trees. In other words, there is such a state of affairs as being so closely associated with a general movement and so enthusiastic about it that progress along that particular line seems negligible or tortuously slow. Even a conservative biological scientist or the most effervescent nature advocate should be able to recognize, however, that the advances within recent years in the formation and growth of a sound renewable natural resources program in Illinois have been extraordinary. In view of the fact that I am speaking about a program involving a large governmental unit and an extensive geographical

area, I believe that I am justified in using the term "recent" to cover a period of about five years. Governmental action in a democracy ordinarily proceeds slowly because it is not brought about by fiat.

Support through the press.—One of the outstanding advances in Illinois and the nation during this period has been the sudden, almost explosion-like, increased interest upon the part of all classes of citizens in the preservation and increase of forest and wildlife resources. A good gauge or yardstick for measuring this increase is the prominent space given by the press, both rural and metropolitan, to publicity concerning the kinds of these resources, their values and necessity in our present niche of civilization, and descriptions of enterprises having to do with their promotion or development. Newspapers and magazines have a way of appraising subject matter of interest to the public, and the columns of space being devoted to forests and wildlife resources are highly indicative of reader interest. This means better and sounder conservation programs by virtue of public support and interest.

Support through organizations.—Another indication of the great advance during recent years in renewable natural resources appreciation is the present number of organizations entirely or in part dedicated to furthering such programs. Fifteen or twenty years ago such organizations were not so numerous and possessed little numerical strength. Fishing and hunting clubs, to be sure, were somewhat of an exception to this statement, but in most instances their membership was not sponsoring the type of conservation now rampant throughout the country. Today almost all large civic organizations such as garden and women's clubs, and the Boy and Girl Scouts, have definite departments promoting the cause of conservation. In addition, we have within the State numerous other laymen organizations, such as the Izaak Walton League, Farmers-Sportsmen's Clubs, Conservation Council, Associated Conservation Organizations of Illinois, Illinois Audubon Society, Prairie Club, Wild Flower Preservation Society, Wilderness Society, American Forestry Association, dedicated solely to such programs and interests. One of these organizations, the Illinois Farmers-Sportsmen's Club, has a membership in this State at the present time of about 80,000 members.

Such an aroused public interest has in turn stimulated the scientific study of our renewable natural resources and forced the reevaluation of conservation theories and practices, many of which, unfortunately, have been and are being found quite wanting. Three years ago there was held at Urbana under the sponsorship of the State Natural History Survey a Wildlife Conference, the first of its kind in the Middle West and perhaps in the country. This was essentially a fish and game clinic at which scientists from all the north-central states, without being dominated by administrators or the political type of conservationists, freely discussed wildlife management practices in an effort to winnow out the chaff from the wheat, to coordinate such researches and to orientate scientific studies of wildlife resources in such a way that demonstrable sound management practices would result. This conference is now an established affair between the states concerned and has served, too, as a forerunner of nation-wide activities along this line. Conservation activities in the past, except possibly in the case of forestry, have been exceedingly wasteful of public monies, have had policies based largely upon fancies and undemonstrated assumptions, and often have been directed by individuals who knew little of and cared less for the biological or scientific principles involved.

National forestry program.—The biggest single advance in the renewable natural resources program of this State in the last five years was the establishment in southern Illinois of a national forest unit. I am glad to say that the Illinois State Academy of Science, through its conservation committee, actively supported this forward-looking movement and that the foundation for its being was laid by the Natural History Survey over a period of years. Because of soil values and present land uses the area for a national forest unit breaks into two separate parts, each of which, however, is a single large administrative unit.

Time forbids a detailed statement concerning the accomplishments to date within this national forest unit but they are many, varied and of out-

Fig. 6.—Fire tower on High Knob, Hardin County. Many such towers have recently been built to aid in giving fire protection to national and state forests of Illinois.

standing importance. During the past four years 125,033 acres have been purchased by the Forest Service and an additional 32,525 acres have been optioned and approved by the Reservation Commission. Slightly over 20 per cent, therefore, of the 784,000 acres gross area within the approved unit boundaries have been purchased or are in process of acquisition. This is a great advance, indeed, and 25 years ago the most enthusiastic advocate of an increased forestry program in Illinois would have shied at predicting such an accomplishment. Fire control on this area has steadily advanced and there are now 14 primary and secondary lookout towers with a connecting telephone system to aid this work. Fire control means the growth of new forests, a reduction in soil erosion, a decrease in the silting of streams and generally-improved wildlife conditions. Other accomplishments involved extensive new road construction and the improvement of old ones, the development of recreational centers for picnicking and camping, the reforestation and planting of badly-eroded spots to the extent of some 1,766 acres in 1937, establishment of forestry experimental plots, the Dixon Springs pasture and soil erosion project in cooperation with the Farm Security Administration

Fig. 7.—One of the State nurseries that raise forest trees. The Thompson Tree Nursery, near Anna. Photo courtesy State Dept. of Conservation.

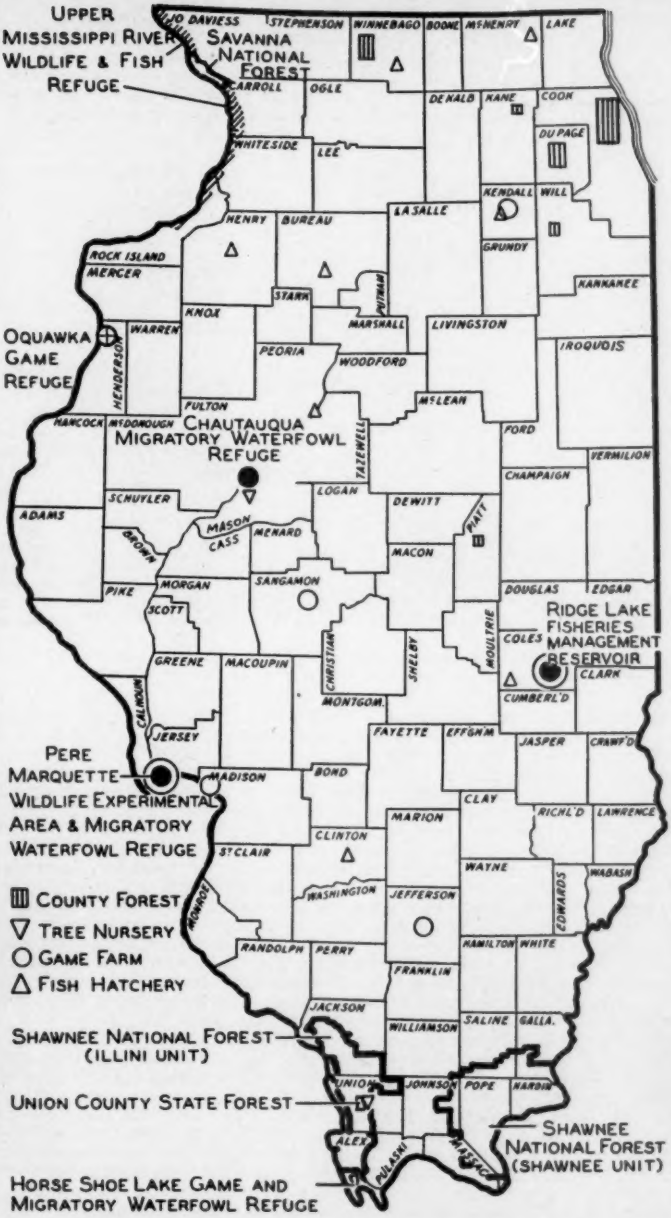


Fig. 5.—Forest, game and fish development areas in Illinois.

and the University of Illinois, the construction of 45 ridge ponds or catch basins to further wildlife, particularly during drouth periods, the completion of ranger station buildings at Murphysboro and Jonesboro, and plans for the development of experimental and game refuge areas in cooperation with the State Natural History Survey. It should be stated in connection with this record of accomplishments that CCC and relief labor supplied most of the man power and without this aid the program could not have been so far advanced.

State forestry program.—The State Division of Forestry also has made noteworthy advances within recent years in the cause of a sound forestry program for Illinois. The State forest located near Jonesboro was acquired

Fig. 8.—The Chautauqua Lake Migratory Waterfowl Refuge, a few miles north of Havana.

only nine years ago and contains 3,482 acres. Within the last few years this area has been greatly improved from the standpoint of recreational use. Although there has been a tree nursery there since 1929 the real development of this nursery, now officially known as the Thompson Nursery, was initiated in 1936. In cooperation with the U. S. Forest Service, the production of this nursery has been stepped up to the extent that some 3,500,000 trees are now produced there annually. In 1934 another State nursery, the Horner Tree Nursery, was established eight miles east of Havana and this nursery has contributed greatly to the production of seedlings, particularly black locust, for erosion control. January 1, the State Division of Forestry, in cooperation with the U. S. Forest Service, under the terms of the Clarke-McNary Law, began to increase nursery stock production and general State forest fire protection, both of which enterprises are real advances in forestry work in this State. Another project which should be mentioned is the forestation of abandoned strip-mine lands in cooperation with mine operators and this spring 400,000 trees have been planted on such areas under direct supervision of the State Department of Forestry. Last, but not least, the last session of the Legislature appropriated $50,000 for the establishment of another new State forest unit which probably will be located in poor-soil-type areas in a central or northern part of the State where it will be accessible to large population centers.

Cook, Will, Winnebago, DuPage, Kane and Piatt counties have done much to improve their county forests for wildlife and recreational uses during the past several years with CCC and relief labor but time prohibits any detailed statement here except to say that, although such holdings are small when compared with State and national forests, they are exceedingly important because of the large number of citizens served by them.

Migratory waterfowl preservation.—Advances in migratory waterfowl preservation have been notable within recent years. Horseshoe Lake, which is host to so many water birds during the migration seasons, is well known to all and will not be considered here because of its comparatively early establishment in 1927. Within the last three years the U. S. Biological Survey has established near Havana, Illinois, a migratory waterfowl refuge of about 4,000 acres. This area has been so improved that once more Chautauqua Lake is a permanent body of water and not a corn field as a result of drainage. Already the area is frequented in fall and spring by many thousands of ducks, geese and other water birds because here they find food and a safe haven. The importance of this refuge in preserving an abundant supply of these valuable resources is very great and marks a big step in a renewable natural resources program both of the continent and of this State. Under a cooperative agreement with the Biological Survey, the State Natural History Survey will use this refuge as a census station and investigational area.

Game research and management.—The State Natural History Survey also has greatly orientated its work and program during the last five years to meet the practical demands of an enlarged and sounder renewable natural resources program for Illinois. The first step in this direction was the establishment, July 1, 1934, of Game Research and Management as a new section of the Natural History Survey, to be coordinated with other investigations in the fields of entomology, applied botany and plant pathology, aquatic biology and forestry. The money for starting this work was released by Governor Henry Horner from a Survey contingency fund, and in 1935 this work was definitely established as an activity directly provided for in the Survey budget by act of the Legislature and approval of the Governor. This program was started with the idea of accomplishing the following objectives:

(1) A general survey of all sections of the State from the standpoint of present and past game resources and more detailed surveys in certain selected areas.

(2) Studies of our more important game species, both bird and mammal, from the standpoint of desirability, food habits, shelter or cover prerequisites, general habits, reproductive capacities, influence of weather conditions, enemies, diseases and parasites.

(3) The establishment of a wildlife technical service to be available to the State Department of Conservation, and other departments of State and national agencies, as well as to layman organizations and private individuals.

(4) The promotion of a game increase program with the farmers of Illinois through sportsmen's clubs, farm bureaus and other agricultural agencies.

(5) The need of dovetailing game management practices with our existing program of fisheries research and forestry extension, because they are all very closely interrelated in subject matter.

Experimental wildlife areas.—The money provided in 1934 and following years has enabled the Survey to add to the staff a well-trained game specialist and to provide him with a part-time winter and full-time summer assistant. This newly-established service rapidly demonstrated its value and it soon became evident that this personnel was inadequate to meet the demands of this new program throughout the State and at the same time to establish by investigations the basic scientific data necessary. In 1937 the State Legislature appropriated additional funds to the Natural History Survey to strengthen and expand its program and staff for carrying on this work. By 1936 it had become evident that in order to get the type of scientific data necessary for the management of game resources it was necessary to establish some outdoor experimental areas for extensive censusing with regard to fluctuations of wildlife populations and to test out management theories for both fish and game under practical conditions. This new appropriation of 1937 was released by Governor Henry Horner on January 1, 1938, and is enabling the Survey to establish such experimental areas in cooperation with other State and federal agencies which are in a

position at this time to aid such programs by supplying land, personnel of a varied type and the labor of CCC camps.

Two large projects are now under way as a result of this action, and these, I believe, have every possibility of returning to the State in the form of valuable scientific data, in the preservation of certain wildlife resources, and by demonstration of tested management practices, contributions which will be equal to or exceed the total combined work of this nature which has been done by various state agencies to date.

Fig. 9.—A minor channel connecting the Mississippi and Illinois Rivers near Grafton. This borders the Pere Marquette Wildlife Experimental Area and Migratory Waterfowl Refuge.

Pere Marquette Area.—The first of these projects has been named the Pere Marquette Wildlife Experimental Area and Migratory Waterfowl Refuge. It is located in the extreme southern tip of Calhoun County, between the confluence of the Illinois and the Mississippi rivers. It gets the first part of its name from the fact that it will be adjacent to Pere Marquette State Park, now being extensively developed by the State Department of Public Works and Buildings and the National Park Service. As the rest of its name implies, this outdoor laboratory will be dedicated to the scientific study and practical management of the renewable natural resources of this area and will serve as a refuge or haven for the migratory waterfowl which use the Illinois and Mississippi river valleys as flyways during their spring and fall migrations. If this area contributed nothing else to the cause of conservation in this State except to furnish a safe haven for such valuable birds, located as it is about halfway between Horseshoe Lake Refuge of the State Department of Conservation and the Chautauqua Lake Refuge of the U. S. Biological Survey, it would be worth every cent of its cost. In developing this project, the National History Survey has been most fortunate to secure the active cooperation of the U. S. War Department, which, because of the installation of the locks in the Mississippi River near Alton and the resulting impounding of the waters at the 420-foot contour, has found it necessary to purchase this bottom land. About 3,000 acres of this land, at the location already mentioned, is now being developed for this experimental area and refuge in cooperation with the National Park Service and the State Department of Public Works and Buildings. Several additions to the staff of the Natural History Survey have been made for the express

purpose of carrying out the scientific program on this and other tracts of the same fundamental character within the State.

Besides serving a number of valuable scientific purposes, this area will be so developed that under certain conditions and times it will be available for visitation by the general public interested in the wildlife of the State;

Fig. 10.—Aerial view of the Pere Marquette Experimental Area and Migratory Waterfowl Refuge.

thus serving as a demonstration project and adding greatly to the recreational and educational features of the Pere Marquette State Park and the adjacent U. S. Recreational Demonstration Area.

Ridge Lake.—The second project now in course of development is the building of a small experimental reservoir of about 23 acres in the Fox Ridge State Park southeast of Charleston, Illinois, to be known as Ridge Lake. This reservoir is being so constructed that it will enable the Survey to carry on a fisheries management program such as cannot be duplicated at the present time anywhere in the State and probably in the country. Soil maps have been made by the Soil Survey of the Illinois Agricultural Experiment Station. The State Geological Survey has contributed to a detailed mapping of the basin and supplied other geological information in connection with the dam site. The State Water Survey has contributed information concerning the availability of surface waters and assisted in the designing of a dam of unique type which will enable us to control the reservoir from the standpoint of its fisheries management. Not only will this project contribute important information for the guidance of future reservoir construction in the State in regard to utilization of wildlife resources, but it will form also a valuable asset to the aesthetic and recreational features of the park. This project has been made possible by the cooperation of certain agencies already mentioned, the citizens of Charleston who provided the money to buy additional private lands for increasing the park area to accommodate the reservoir, the State Department of Public Works and Buildings and the

National Park Service. The labor, as in the case of the Pere Marquette Experimental Area, is being provided by relief and CCC camps. A small laboratory will be established there to house equipment and personnel utilized in making a detailed study of this lake as it passes through various stages so that such matters as plankton development, change in chemical content of the water, development of bottom fauna, vegetation and fish populations can be studied in relation to maximum fisheries production in such waters. A limnologist has been added to our Section of Aquatic Biology especially to handle the investigational program centered around this reservoir and to work on State reservoir problems in general as they affect fish and other wildlife resources.

National forest experimental area.—A third experimental area and refuge, typical of the Ozarkian Uplift and not far from Carbondale, is now reaching a stage which augurs well for its official inauguration within a few months. This is an experimental area and refuge in the National Forest Unit to be developed in cooperation with the U. S. Forest Service. The staff and personnel employed to carry on the experimental program in the Pere Marquette Refuge and Ridge Lake Reservoir will promote research and management practices in this area and will be aided by members of the scientific staff of other sections of the Natural History Survey and the U. S. Forest Service.

All three of these projects are fundamentally different, the Pere Marquette Area stressing migratory waterfowl resources, the U. S. Forest Area emphasizing upland game and fur-bearing mammal populations and Ridge Lake in Fox Ridge State Park the management of our most important game fish. These three projects represent a marked departure in the scientific program of the State, since they introduce the element of scientific field studies in representative water or land type areas in contrast with indoor laboratory researches. Both types of study are essential and must supplement one another, particularly when the State is faced with a dynamic and practical renewable natural resources management program.

Pittman-Robertson Act.—Another most important step, although not completely taken, is so definitely a part of the near future that it should be mentioned at this time; this is a federal bill known as the Pittman-Robertson Act. This legislation passed the national Congress last year and sets aside in the federal treasury certain taxes on munitions to be used to aid state programs of game restoration. It is modeled after the national highway legislation which brought the country out of the mud and gave us a unified and coordinated highway program. This bill is very carefully written and so set up that money will go only to states which have a sound program for game restoration. The money is distributed in proportion to the area of a state and the number of hunting licenses issued. Illinois ranks well with most other states in area of square miles and stands about fifth in number of hunting licenses issued; all of which guarantees a considerable allotment of funds to this State. As I have already mentioned, this money is to be used for the actual restoration and development of wildlife areas and the promotion of scientific studies which will aid in the preservation and increase of desirable wildlife populations. Over a period of years, the funds available should accomplish a great deal toward these ends. From all points of view, I believe that this is the most important national or state bill which has been passed to aid wildlife resources in the states and country at large since the passage of the first Migratory Bird Act in 1913 and the establishment of national parks and forest units.

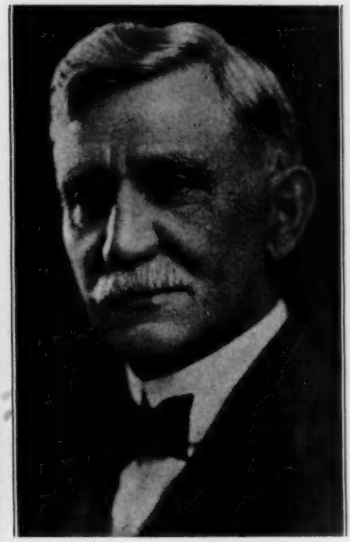
Prospects for the future.—Although you and I, as conservationists, are in the same position as the housekeeper watching the kettle which seemingly never boils, rapid advances in the renewable natural resources program of this State and the country are being made. This means, too, that the preservation of most of our remaining renewable natural resources in Illinois is assured and that the decline in numbers of certain wildlife populations is being stopped. In addition, there is every prospect that, within certain limits, there will be increases of certain desirable wildlife populations and an improved technique available for intelligently managing our woodlands, farms and inland waters.

MEMOIRS

CHARLES BEACH ATWELL

1855–1937

INSTITUTIONS which need defence are, in general, either those which have outlived their usefulness or those whose merit the public has not yet discovered. With this principle in mind the charter-members of an association are usually held in high respect. Thus our Academy cherishes the memory of the group who, more than thirty years ago, first recognized the need of presenting to the people of Illinois, in easily understood style, the important results of modern science; and we therefore pause to pay tribute to one of our recently deceased charter members.



Professor Atwell was born on the 11th of April, 1855, at Theresa, N. Y., near the point where the St. Lawrence river takes its rise in Lake Ontario. He died at the home of his daughter, Mrs. John A. Detlefsen, in Swarthmore, Pa., on the 14th of September, 1937.

His college training was received at Syracuse University where he graduated Ph.B. in 1879 and where he was honored with an Sc.D in 1929. His interest in botany was early awakened; and advanced work in this subject was pursued during the summer of 1887 at Harvard and during the year 1891 at Freiburg in Baden. The years from 1880 to 1888 were spent in the public and the secondary schools of Evanston, Illinois.

His marriage to Miss Mary J. Kellogg took place in 1883. Three of their four children, Henry, William, and Ruth are still living; but Mrs. Atwell died eight years before her husband. Professor Atwell's long connection of forty-nine years with Northwestern University began in 1888 when he was appointed to an instructorship in biology in that institution. At the end of the first three years he was promoted to a professorship of biology. At the end of another three years, the responsibility of his chair was divided; and Professor E. G. Conklin was called to the new chair of zoology, whole Professor Atwell accepted the new chair of botany which he held until his retirement in 1927 with the title of Professor Emeritus. His contributions to botany were mainly along the line of algae and dune plants.

In addition to the direction of the botanical laboratory at Northwestern University, Atwell discharged many other duties. He was for twelve years Registrar of the College of Liberal Arts. For two years he was City Forester of Evanston, a densely wooded area covering several square miles. In the Chicago Academy of Science and in the Science Club of Evanston, he was always deeply interested and active. During all his years at Northwestern he gave himself unselfishly to the collection of historical data concerning its alumni; and in 1903 published a volume of 464 pages which still forms the authoritative story of these graduates up to that date.

To confine this notice to his training and to his university work would be to give a very imperfect and incomplete picture of Charles B. Atwell: for he was so generous with his time, energy and sympathy that friends and strangers were constantly calling upon him to perform a thousand and one kind offices. When the University Club of Evanston was established in 1904, Atwell was chosen as its first president. As a traveling companion on walking, wheeling and fishing trips in the mountains, the present writer can bear witness to his ever buoyant spirits and—severest test of friendship—to his persistent good nature when the rain was pouring and the rations short. In cases of severe illness or death, he was one upon whom his colleagues leaned heavily. In church work, in municipal affairs and upon all public questions, he was on the side of charity, justice and square dealing. His life was, indeed, a blend of courage, constancy and courtesy.

HENRY CREW.

LOUIS E. HILDEBRAND

1871–1937

LOUIS E. HILDEBRAND was born at Zoar, Indiana, January 30, 1871. After leaving the rural schools there he attended Valparaiso University, where in 1901 he obtained his B. S. degree. After receiving an A. B. degree from Indiana University in 1904, he taught in country schools near Stendal, Indiana, until he could attend Northwestern University. There, in 1909, he won his M. A. degree. From then until the time of his death he taught in the biology department of the New Trier High School, Winnetka, Illinois. He died at his home, 1620 Ridge Avenue, Evanston, on September 12, 1937.

He was a member of the State Academy of Science for many years. He also belonged to the Progressive Educational Association, the Illinois Educational Association, the National Education Association, and the Central Association of Science and Mathematics Teachers, of which last he was vice-president in 1932. An extensive traveler, he visited and studied in various parts of Europe, including Iceland and the Scandinavian countries, and made many trips to augment his knowledge of his own United States, of Canada, and Mexico.

An excerpt from the student year-book of New Trier High School shows the appreciation of a large group who knew him well:

> "For twenty-nine years 'Hilde,' as he was affectionately but not disrespectfully referred to, has touched the lives of New Trier students. He was an inspiring teacher, a tireless scientist and a loyal friend. He was born, raised and educated in the rugged hill country of southern Indiana. . . . With him education was a continuous process; so he traveled to the remote corners of the earth in his quest for more and more scientific information. The New Trier Biology Museum, filled with evidence of this force which forever drove him on, will, on September 12, 1938, the anniversary of his death, be dedicated to his memory."

F. C. Windoes

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ARTHUR WARE SLOCOM

1860–1937

SCIENCE is served in many ways. She is doubtless fond of her spectacular minions whose names commonly appear on important tomes, but certainly she must also cherish her unsung servants who are merely listed in the same works as those "to whom acknowledgments are due." High in the ranks of the latter stood Arthur Ware Slocom, assistant curator of invertebrate paleontology at Walker Museum, University of Chicago, who died on November 20, 1937, in his seventy-eighth year.

Mr. Slocom was born in Milford, Massachusetts, on November 8, 1860, the son of Lewis Slocom and Lucinda Ware. He derived a modest satisfaction from the fact that his ancestry was interwoven with the warp and woof of Colonial New England's best. He was a descendant of Dr. Samuel Fuller of the Mayflower, and six of his forebears were Minute Men who responded to the Lexington Alarm of April 19, 1775. It is not surprising, therefore, that he was an ardent and accomplished genealogist, and for a score of years was an officer of the Illinois Society, Sons of the American Revolution.

After a common school education Mr. Slocom went to Milwaukee to enter the straw hat business with an uncle. An increasing interest in science led him to enroll in 1896 for special work in paleontology under Dr. Stuart Weller at the University of Chicago. Although Dr. Weller was ten years his junior, there thus began their happy thirty-year relationship of mentor and student, terminated only by Dr. Weller's untimely death in 1927. At Dr. Weller's suggestion Mr. Slocom spent the year 1898–99 at Ward's Natural Science Establishment at Rochester, N. Y. The next year he was a member of the staff of the Milwaukee Public Museum. Then began in 1901 a profitable thirteen-year term as invertebrate paleontologist for the Field Museum of Natural History, Chicago. In 1914 he again became directly associated with Dr. Weller as assistant curator at the Walker Museum, a position which he held with quiet competence for twenty-three years.

Mr. Slocom published a number of papers between 1906 and 1924. Of these, eight, dealing almost entirely with fossil echinoderms and trilobites, represent significant researches. His major contributions to science, however, are not to be found in his publications. He arranged and catalogued the largest collection of Paleozoic invertebrates in any educational institution, prepared hundreds of fossils for study, made up the plates for innumerable papers, and, more or less surreptitiously, guided literally dozens of candidates for the doctorate through their thesis problems. Little wonder that scores of genera and species of Paleozoic fossils have been named in his honor.

Mr. Slocom, whose perpetual good humor and self-sacrificing character were proverbial, was intellectually keen until the day of his death, having been working on Devonian trilobites the last few weeks of his final illness. He is survived by his wife, an adopted daughter and by many generations of graduate students whom he regarded as "his boys," and who, to a man, rightly feel that "Walker Museum can never be the same again."

CAREY CRONEIS.